

## X<sub>2</sub> Update

Wim Kimmerer

This article brings up to date the status of X<sub>2</sub> and the relationships between abundance or survival of various species and X<sub>2</sub> described by Jassby *et al* (1995).

X<sub>2</sub> was calculated for 1968-1991 by interpolating surface salinity values from a series of continuous monitoring stations and correcting for stratification (Jassby *et al* 1995). The resulting daily time series and the monthly means were then fit to time series models to predict X<sub>2</sub> from net delta outflow and the previous day's (or month's) X<sub>2</sub>. These models were then used to extend the X<sub>2</sub> time series to the end of water year 1995 using delta outflow from the DAYFLOW model, and through water year 1996 using estimates of daily outflow provided by DWR. For each species, X<sub>2</sub> was averaged over a time period based on the ecology of the species and the collection method, as discussed in Jassby *et al* (1995).

Abundance data were obtained from DFG either as annual abundance indices or as abundance estimates, which were averaged by year. Models generally identical to those reported by Jassby *et al* (1995) were fit to the data for the same period (typically through 1990 or 1991), and the points added after that were inspected for deviation from the values predicted by the models. The exception was for mysids (*Neomysis mercedis* and the introduced *Acanthomysis* spp. combined), for which a log link function was used, with variance proportional to mean squared.

Figure 1 shows the entire time series of X<sub>2</sub> values (A) and a subset for 1991-1996 (B). The periods of high flow in the first half of 1995 and early spring of 1996 are evident in Figure 1B.

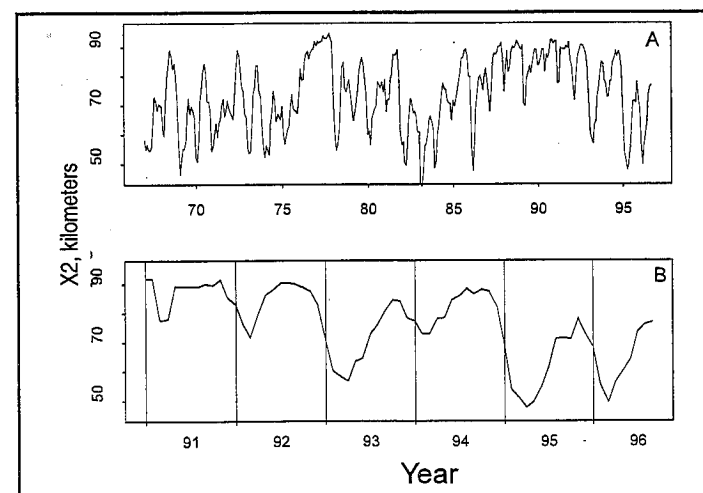


Figure 1  
TIME SERIES OF MONTHLY ESTIMATES OF X<sub>2</sub> FOR  
CALENDAR YEARS 1967-1996 (A) and 1991-1996 (B)

In bringing some of the relationships between abundance and X<sub>2</sub> up to date, it became apparent that some of them show signs of depression for the years since 1988, the year when the clam *Potamocorbula amurensis* was first observed to affect zooplankton (Kimmerer *et al* 1994). Figure 2 shows four of the relationships and indicates the points occurring after 1988. Mysids were less abundant than predicted by the regression line in all years but one, and in all years of high flow and low X<sub>2</sub>. The bay shrimp *Crangon franciscorum* was less abundant than predicted in several years, but in 1996 it had its highest-ever abundance index and the point fell well above the prediction line. Starry flounder has been at depressed levels of abundance since 1988, and abundance of longfin smelt has been lower than the line for the last 3 years.

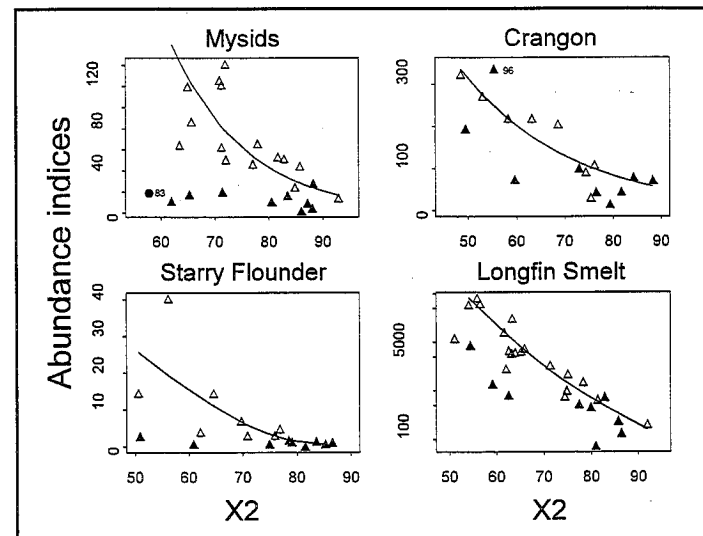


Figure 2  
RELATIONSHIPS OF X<sub>2</sub> TO ANNUAL MEAN ABUNDANCE OF MYSDS  
AND ANNUAL ABUNDANCE INDICES OF  
CRANGON FRANCISCORUM, STARRY FLOUNDER, AND  
LONGFIN SMELT  
Solid triangles indicate points from 1988 on, and numbers indicate years.  
The single point for 1983 in the mysid graph was not used in fitting the line.  
See Jassby *et al.* (1995) for details of methods used to fit lines to the data.

The continued depression of some, but not all, species below the levels predicted by the regression lines may indicate an effect of *P. amurensis* at several trophic levels above those feeding directly on phytoplankton. Depressed spawning stocks would not appear to explain these low values, since we have had several years of sufficient flows to have otherwise raised these stocks to high levels.

## References

- Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R. Schubel, and T.J. Vendliniski. 1995. Isohaline position as a habitat indicator for estuarine populations. *Ecological Applications* 5:272-289
- Kimmerer, W.J., E. Gartside, and J.J. Orsi. 1994. Predation by an introduced clam as the probable cause of substantial declines in zooplankton in San Francisco Bay. *Mar. Ecol. Progr. Ser.* 113:81-93.

## Suisun Marsh Salinity

Dawn Friend, DWR

Salinity levels in Suisun Marsh are influenced by many environmental factors, both natural and human-induced. Tides, tributary inflow, and rainfall are a few of the natural factors; human-induced factors include SWP and CVP operation, upstream diversions, salinity control gate operation, and operations of managed wetlands in the marsh. How these factors interact is not fully understood, but continual monitoring and data analysis help identify overall trends. For the purpose of identifying annual trends in 1996, four basic factors affecting salinity levels are discussed:

- Delta Outflow Index
- Salinity Control Gate operation
- Managed wetland operation
- Tributary inflow

The Delta Outflow Index is an index of the net rate of water moving out of the delta into San Francisco Bay. High index values indicate a large volume of fresh water flowing through the delta and is usually coincident with lower salinity levels in Suisun Marsh. Conversely, low index values are usually coincident with higher salinity levels. In the first half of 1996, the Delta Outflow Index was relatively high and salinity levels were low (Figure 1). This trend is reversed during the second half of the year until December, when the index increased significantly and salinity decreased correspondingly.

The Suisun Marsh Salinity Control Gates regulate salinity levels in the marsh by restricting the flow of high salinity Grizzly Bay water into Montezuma Slough during flood tide and holding lower-salinity water in the marsh originating from the Sacramento River near Collinsville. In 1996, the gates were operated for only 2 weeks during November. Figure 2 shows both gate

operation and the November progressive mean of specific conductance at high tide at four stations (Figure 3). (Progressive daily mean is the average of specific conductance measurements made at the peak of high tide from the beginning of the month to the day of interest. Progressive daily mean is reset at the beginning of each month.

Three of the stations — Collinsville (C-2), National Steel (S-64), and Beldons Landing (S-49) — are in Montezuma Slough. The fourth — Chadbourne (S-21) — is west of Montezuma Slough in Chadbourne Slough. Salinity levels at the station closest to the gates (S-64) fell within a few days after the gates began operating. At the next closest station (S-49), salinity levels fell within 4 or 5 days. The station farthest from the gates (S-21) responded less significantly to gate operation after a week. The control gates are believed to increase salinity slightly at C-2 because a greater portion of lower-salinity water is

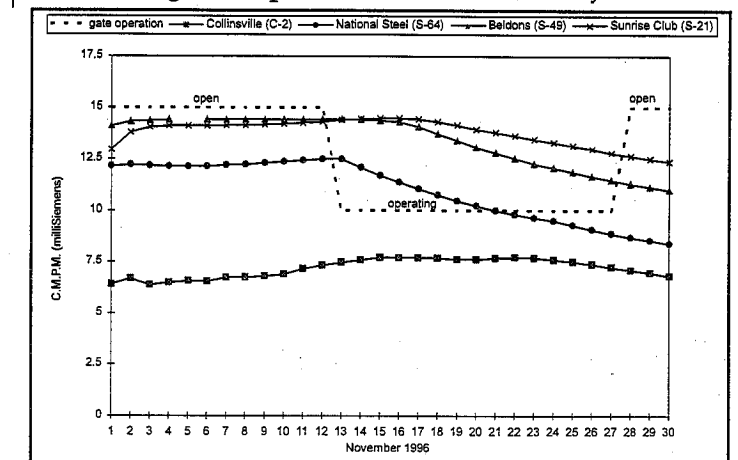


Figure 2  
CALENDAR MONTH PROGRESSIVE MEAN OF  
SPECIFIC CONDUCTANCE AT HIGH TIDE

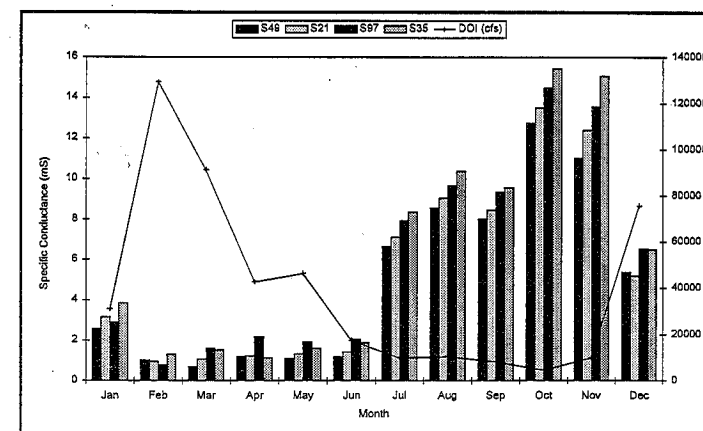


Figure 3  
1996 DELTA OUTFLOW INDEX AND SPECIFIC CONDUCTANCE

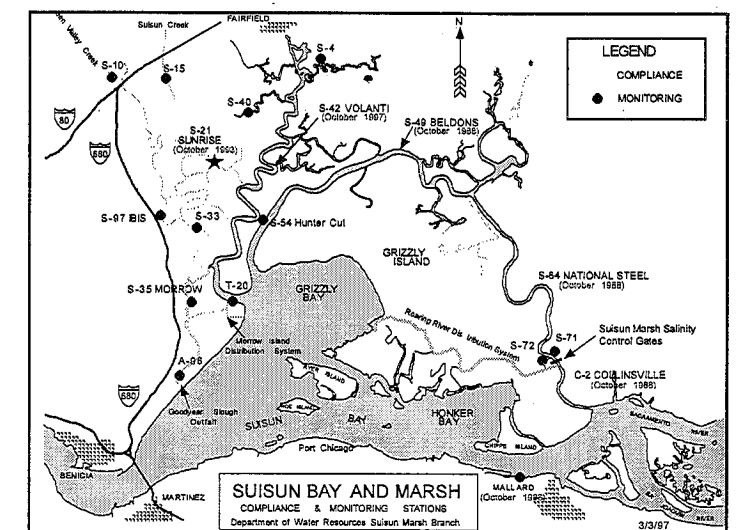


Figure 4  
MONITORING STATIONS IN SUISUN BAY AND MARSH

diverted into Montezuma Slough. However, the volumes exchanged are arguably small enough for salinity levels at C-2 to be used as a baseline condition.

Seasonal operation of privately and publicly owned managed wetlands also influences salinity levels in Suisun Marsh. Wetland managers flood and circulate water during the waterfowl hunting season and conduct leaching cycles after hunting season. Flooding typically begins in October and circulation continues through February. Incoming water is pumped from sloughs onto the wetlands, in effect removing less-saline water from the sloughs and allowing more-saline tidal water to move farther into the marsh. The leaching cycles, necessary to decrease soil salinity in the wetlands, involve a series of short-duration flooding and draining cycles. Leaching usually begins in February and continues for 1-4 months. Drain water is much more saline than flood water, contributing to higher salinity levels in the marsh. In 1996, the highest salinity levels were in October, coinciding with the flooding cycle. During the early part of 1996, salinity was relatively low despite the leaching cycles, probably due to the high Delta Outflow Index.

Tributary flow is a primary source of fresh water in Suisun Marsh, especially the western marsh. The two main tributaries are Green Valley Creek (S-10) and

Suisun Creek (S-15). Creek flow affects salinity in the western marsh in the same manner as the Delta Outflow Index; higher creek flows result in lower salinity, lower creek flows result in higher salinity. During the first half of 1996, higher creek flows are accompanied by lower salinity levels (Figure 4). As the year progressed, creek flows decreased and salinity levels increased. Creek flows are presumed to have increased during December, given the amount of rainfall at the end of the year (data unavailable), corresponding with decreased salinity levels during December.

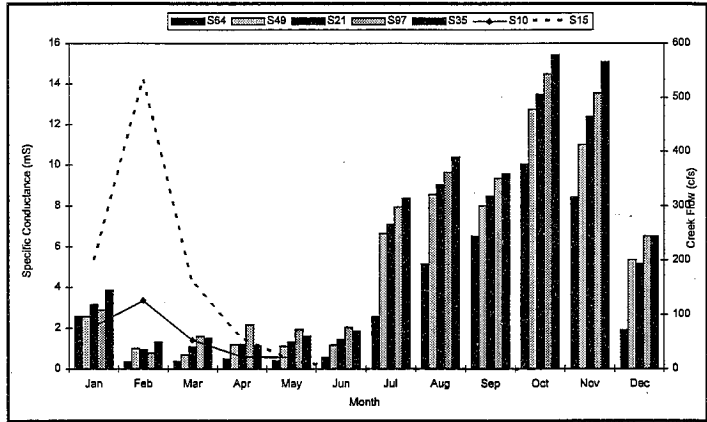


Figure 4  
1996 TRIBUTARY INFLOW AND SPECIFIC CONDUCTANCE

### Neomysis/Zooplankton Abundance

Jim Orsi, DFG

Compared to 1994 and 1995, there were no marked changes in abundance of any taxon of mysid shrimp or zooplankton in 1996 except the brackish water rotifer, *Synchaeta bicornis*, which rose sharply (Figures 1-4). *Synchaeta bicornis* is most abundant in summer and fall — too late in the year for it to be responding to high spring outflow.

Abundance of the copepod *Eurytemora affinis*, an important larval striped bass food, has remained fairly constant since 1989. Its abundance appears to have “bottomed out” and the volume of outflow seems to have little influence on its abundance. It is typically most abundant in the San Joaquin River at Stockton and in Disappointment Slough, upstream from the influence of the Asian clam, *Potamocorbula*, which is believed to feed on its early life stages and on its food supply, phytoplankton. *Eurytemora* tends to peak in April and May, declines in June, and is absent from our catches by July. It reappears in late fall and early winter.

The abundance of the introduced *Sinocalanus doerrii* has also “bottomed out”. It showed little variation in abundance in 1994-1996. Its last year of moderate abundance was 1993. The abundance of *Pseudodiaptomus forbesi*, a copepod from China that has replaced *Eurytemora* in the entrapment zone, has varied somewhat since its introduction in 1988. Its abundance peaked in 1992. Its lower abundance in 1993-1996 has not been accompanied by an increase in *Eurytemora*, although it is suspected of competing with *Eurytemora* for food. This does not negate the competition hypothesis, because *Pseudodiaptomus* may still be abundant enough to suppress *Eurytemora*.

The coastal marine copepod *Acartia*, which comprises several species and is most abundant downstream from our sampling area, has not been abundant since 1992. Its abundance in our catches was formerly influenced strongly by outflow, but since 1992 its abundance has been low regardless of the volume of outflow. Both

*Potamocorbula* and a predatory copepod from Korea, *Tortanus dextrilobatus*, could be affecting *Acartia*.

The introduced mysid shrimp *Acanthomysis* remained more abundant in 1996 than the native *Neomysis mercedis* but did not show any increase over 1994 and 1995. Both of these mysids may be food-limited by the grazing of *Potamocorbula*.

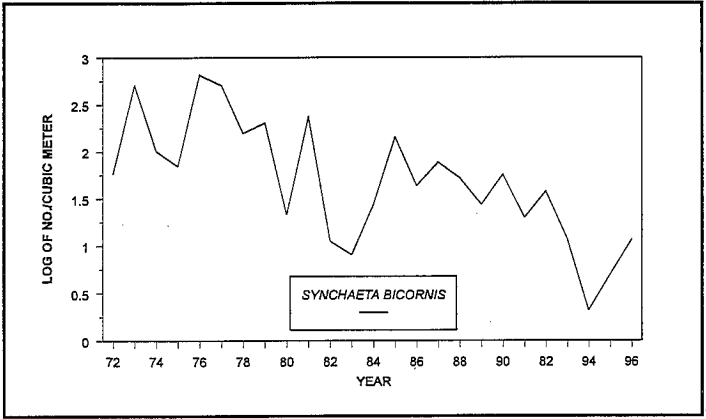


Figure 1  
ABUNDANCE OF *SYNCHAETA BICORNIS*

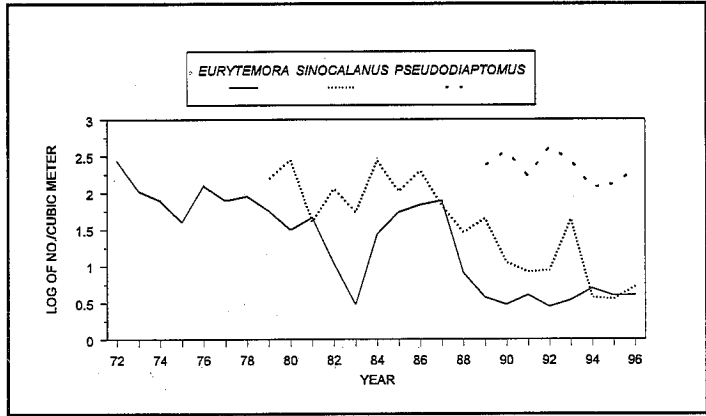


Figure 2  
ABUNDANCE OF  
*EURYTEMORA*, *SINOCALANUS*, AND *PSEUDODIAPTOMUS*

With the passage of each year it becomes more certain that abundance of the native copepods and *Neomysis* is controlled and kept at low levels by introduced species and that freshwater outflow has little impact on abundance.

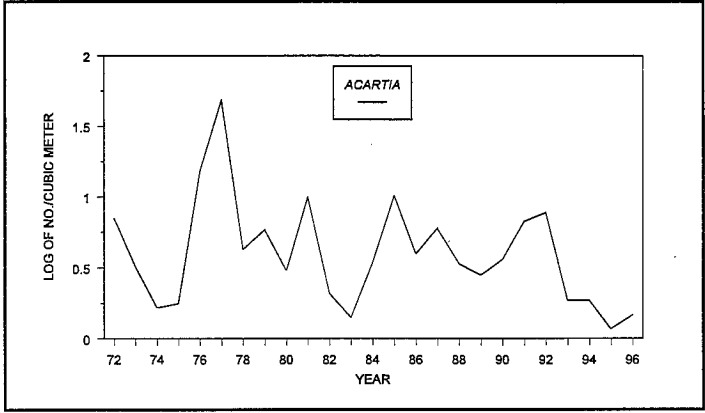


Figure 3  
ABUNDANCE OF *ACARTIA*

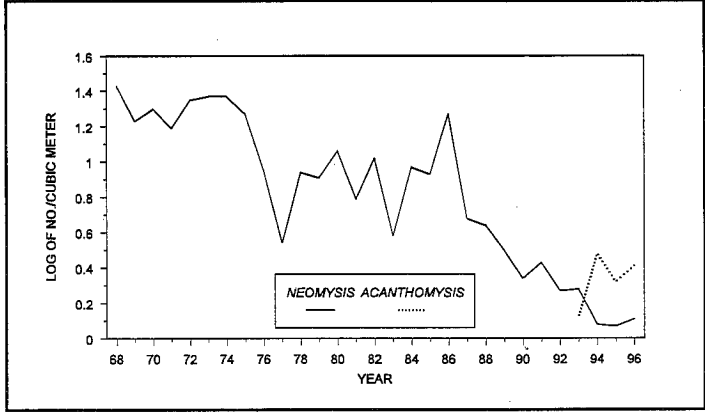


Figure 4  
ABUNDANCE OF *NEOMYSIS* AND *ACANTHOMYSIS*